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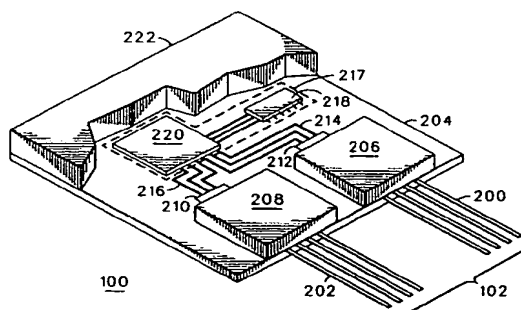
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(54) **A smart optical connector and smart optical connector system.**

(57) A smart optical connector (100) sends and receives optical signals over optical fibers (200, 202). The smart optical connector (100) is capable of converting electrical signals to optical signals for transmission, and capable of converting optical signals to electrical signals for reception. Additionally, the smart optical connector (100) comprises circuitry (217) for modifying the format of the electrical signals to provide compatibility between various equipment (414, 416, 418) which require differing formats.

**FIG. 2****EP 0 650 082 A1**

Background of the Invention

The present invention relates, in general, to connectors for electronic equipment, and more particularly, to smart optical connectors.

It is sometimes desirable to provide communications between two or more electronic devices with optical cables. Optical cables provide extremely large bandwidths which allow tremendous amounts of data to be transmitted at very high speeds. However, the use of optical cables gives rise to a variety of challenges.

It should be understood that typical electronic equipment requires data and other signals in electronic form. In order to use optical cables for the communication of these electrical signals, the electrical signals must be converted into optical signals, and back again into electrical signals. Furthermore, particular types of electronic equipment require data and other electrical signals in corresponding particular formats. For instance, there are a variety of industry standards and specifications to which various equipment are built. Examples are equipment requiring signals and data formatted according to the industry standard RS 232, as well as equipment requiring signals and data according to the industry standard IEEE 488.

In the past, separate systems have been provided to convert the electrical signals and data into optical signals for transmission over optical cables, and to convert one electrical signal and data format into another, as necessary to interlink various different equipment.

What is needed is a way to interconnect differing types of electronic equipment, using optical cable, which does not require one system for reformatting electrical signals and data and a separate system for converting electrical signals to optical signals for transmission over the cable.

Brief Description of the Drawings

FIG. 1 is a top view of a smart optical connector system in accordance with a preferred embodiment of the present invention;

FIG. 2 is a perspective cut away view of a smart optical connector in accordance with a preferred embodiment of the present invention;

FIG. 3 is a bottom view of the connector of FIG. 2; and

FIG. 4 is a schematic diagram of a distributed data bus network employing smart optical connector systems in accordance with a preferred embodiment of the present invention.

Detailed Description of the Drawings

The present invention consist of a fiber optic ribbon terminating at the end in one or more modules permanently attached to the ribbon. The module is capable of both sending and receiving optical signals. A optical signal received will have additional processing carried out by the module in order to provide the equipment electronic data in the correct format for the equipment to correctly use transmitted information. In turn data generated by the equipment is received in an electronic format, processed in an appropriate manner and transmitted in an appropriate optical format.

The processing carried out by the module may be programmed during manufacture or may be actively modified by the sending or receiving equipment allowing it to perform various functions depending on the requirement.

Turning now to the figures for a more detailed understanding, FIG. 1 is a top view of a smart optical connector system 101 in accordance with the preferred embodiment of the present invention. Specifically, system 101 includes smart optical connector 100, optical cable 102 and smart optical connector 104. The workings of the connectors are described in more detail below. In the preferred embodiment, optical cable 102 comprises twenty optical waveguide fibers which may be glass or plastic, or other suitable materials, as is well known in the industry. Any industry standard fiber may be used, however care must be exercised in matching maximum transmission loss to the intensity and wave length of the optical signal.

According to the preferred embodiment, ten of the twenty waveguide fibers are for transmission of data in one direction, e.g., from connector 100 to connector 104. Furthermore, the other ten fibers are for transmission of data in the other direction, e.g. from connector 104 to connector 100. It will be understood, however, that a one way cable may be appropriate under certain circumstances. Additionally, it should be understood that any number of fibers may be employed as one directional or bi-directional. Optical cable 102 may also be referred to as an optical waveguide cable.

Turning to FIG. 2 for a more detailed description of the smart optical connectors, FIG. 2 is a cutaway perspective view of smart optical connector 100 shown in FIG. 1. Smart optical connector 104 shown in FIG. 1 may be identical to connector 100 in certain applications. However, it should be understood, as will become more apparent with the following discussion, that connector 104 may vary somewhat from connector 101, particularly with regard to the electronic processing circuitry within the connector.

As indicated in FIG. 2, a first group of optical fibers 200 combined with a second group of optical fibers 202 compose optical cable 102 shown in FIG. 1. In the preferred embodiment, fiber groups 200 and 202 each comprise ten fibers. Each group is responsible for a single direction of communication, i.e. transmit or receive. For illustrative purposes, optical fiber group 202 and its related path will be referred to as the receive side, while optical fiber group 200 and its related path will be referred to as the transmit side.

Fibers 202 are coupled to waveguide section 208, which in the preferred embodiment is a portion of Guidecast™. Waveguide section 208 is optically coupled at its output to optical-electrical transducer 210. Since this is the receive side, transducer 210 is an optical signal to electrical signal converter. The guidecast™ 208 consist of precision optical guides which align the optical signal from the optical cable 202 to the active portion of an optical - electrical transducer 210, such as a photo diode or other similar device capable of translating optical signals to electrical signals at the necessary speed.

In the preferred embodiment, the output of optical signal to electrical signal converter 210 is coupled to solid state microprocessor 220 via printed traces 216. In the preferred embodiment, solid state microprocessor 220 comprises a single semiconductor die. Associated with microprocessor 220 is surface mount device 218. Surface mount device 218 represents additional electronic circuitry required for the functioning of the smart connector. Surface mount device 218 is coupled to microprocessor 220 via printed traces 219. Microprocessor 220 and surface mount device 218 together compose electrical processing circuit 217 for processing the electrical signals associated with the transmitted and received optical signals. It will be understood that electrical processing circuit 217 shown is merely representative, and may differ greatly within the scope of the present invention.

Regarding the receive path, signals coming in on fiber group 202 and converted to electrical signals via optical signal to electrical signal converter 210 will be considered standard signals, and may be in any particular electrical signal and data format. Electrical processing circuit 217 is capable of actively altering or adapting the standard electrical signals on traces 216 for a specific application by, for example, altering their format. In the case of the receive path being discussed, the altered signal is coupled to an electrical interface (shown in FIG. 3), which in the preferred embodiment comprises pins of a pin grid array.

Electrical processing circuit 217 is capable of actively altering or adapting the standard electrical signals on traces 216 for a specific application by,

for example altering their format from analog to digital technology. In the case of the receive path being discussed, the altered signal is coupled to an electrical interface (shown in fig.3), which in the preferred embodiment comprises pins of a pin grid array. It will be understood that the electrical interface 100 shown is merely representative, and may differ greatly within the scope of the present invention.

The transmit path associated with fiber group 200 is very similar to the receive path associated with fiber group 202. In the case of a transmitted signal, electrical signals of a particular format pass through electrical processing circuit 217. These signals may be in one particular format and converted to another by circuit 217, or they may pass through circuit 217 unaltered. If two different formats are involved, either may be considered a standard format, and the other a particular format. For example analog data may pass thru the electrical processing circuit for use in an application while portions of the analog data may be converted to digital for a separate use.

The electrical signals are conducted via printed traces 214 to the conductive leads of the Guidecast™ 206. The optical-electrical transducer 212 is connected to the termination of these leads. With respect to this transmit side, optical-electrical transducer 212 comprises an electrical signal to optical signal converter. Converter 212 is precision coupled to Guidecast™ portion 206 in such a way as to align the multiple optical signals with the termination of the optical fibers 200. The electrical to optical signal converter consist of a device capable of generating optical signals at high speeds. These signals may or may not be visible to the human eye. Light emitting diodes and laser diodes are examples of such devices.

In the preferred embodiment optical cable 102 comprising fiber groups 200 and 202, along with Guidecast™ portions 206 and 208, transducers 210 and 212, as well as electrical processing circuit 217 are all included in a single integral unit. In the preferred embodiment, each of the components of the connector are positioned on a common substrate 204. Additionally, the substrate and components are overmolded with molding compound 222. It should be understood that FIG. 2 is a cutaway view, and that in practice molding compound 222 would cover all of the components and a portion of the optical cable near the components.

In the preferred embodiment, each of the components of the connector are positioned on the substrate using well known technology to provide reliable electrical contact to the traces 214, 216. Fiber groups 200 and 202 are connected to Guidecast™ mechanically. Additionally, the substrate and components are overmolded with appro-

priate protective compound to provide environmental and mechanical protection, a premolded cover or a combination of each may serve the same purpose.

Turning to FIG. 3, FIG. 3 illustrates the electrical interface between the electrical processing circuitry of connector 100 and external equipment to which connector 100 would be connected. Specifically, in the preferred embodiment connector 100 takes the form of a pin grid array comprising pins represented by pin 300. Pins represented by pin 300 have one end coupled to the electrical processing circuitry of the connector and the other end coupled to external equipment (shown in FIG. 4). The preferred embodiment pin grid array will meet industry standard pin out configurations such as J.E.D.I.C. or E.I.A.J., in order to be compatible with either board or socket conventions.

It should be understood, however, that although shown as a pin grid array, the connector may take a variety of forms including other industry standard connectors such as D-type connectors.

Turning to FIG. 4, FIG. 4 is a schematic view illustrating distributed data bus network 401 employing smart optical connector systems in accordance with the present invention. Distributed data bus network 401 comprises three pieces of external equipment, 416, 414 and 418. External equipment 416 and 418 are referred to generally, and may take almost any form, including printers, modems, automated equipment, etc. External equipment 414 is shown as a computer terminal, for illustrative purposes. Distributed data bus network 401 further comprises hub 400. It should be understood by those skilled in the art that hub 400 is a hub of the nature well known in the network industry, but particularly adapted for use with the smart optical connector systems in accordance with the present invention.

Computer terminal 414 is connected via optical cable 410 and smart optical connector 412 to hub 400. Optical cable 410 and connector 412 are analogous to cable 102 and connector 100, respectively, shown in FIG. 1. Additionally, although not shown, a connector analogous to connector 104 of FIG. 1 resides in computer terminal 414.

Similarly, external equipment 416 is connected via optical cable 406 and connector 408 to hub 400. Again, a smart optical connector which is not shown resides within external equipment 416.

Furthermore, external equipment 418 is coupled via optical cable 402 and connector 404 to hub 400. Additionally, a smart optical connector which is not shown resides within external equipment 418.

External equipment 416 can be considered a first location external equipment, while external equipment 418 can be considered a second loca-

tion external equipment. The distributed data bus network 401 including hub 400 and the various smart optical connector systems provides for a sophisticated interconnection and switching network. The equipment on the network may require a variety of signal and data formats. The smart optical connector systems are capable of making the equipment compatible with one another.

An optical network created by the smart optical connector system would be utilized to connect a number of multifunctional equipment capable of interactively transmitting information between one another. It will be understood that an infinite number of configurations may be constructed to provide distributed data bus networks.

It should now be appreciated that the smart optical connector provides a method of preprocessing optical data transmitted at very high rates between equipment. The active preprocessing of the optical signal after or before transmission allows equipment requiring various data formats to be interconnected interactively. Smart optical hubs will allow the creation of networks of interactive equipment transmitting at speeds not possible over wire interconnections.

Claims

1. A smart optical connector (100) comprising:
 - an optical cable (102);
 - an optical-electrical transducer (210) coupled to the optical cable (102);
 - an electrical processing circuit (217) coupled to the optical-electrical transducer (210), the electrical processing circuit adapting a standard electrical signal for a specific application;
 - an electrical interface including a first end and a second end (300), the electrical interface coupled at the first end to the electrical processing circuit (217) and at the second end to external equipment (416); and
 - wherein the optical cable (102), the optical-electrical transducer (210), the electrical processing circuit (217) and the electrical interface are included in a single, integral unit.
2. The connector of claim 1, wherein the single, integral unit comprises an overmolded package (222).
3. The connector of claim 1, wherein the single, integral unit comprises a pin grid array connector (100) comprising a plurality of pins (300), and wherein the electrical interface comprises the pins (300).

4. A smart optical connector system (101) comprising:
 - a first connector (100) including:
 - a first electrical interface (300) coupled at a first end to first location external equipment (416) and coupled at a second end to an electrical signal to optical signal converter (210); 5
 - a second connector including:
 - an optical signal to electrical signal converter (212); 10
 - a second electrical interface (300) coupled at a first end to second location external equipment (400, 401) and coupled at a second end to the optical signal to electrical signal converter (212); 15
 - an optical waveguide cable connecting the first connector to the second connector (102); and
 - wherein at least one of the first and second connectors is a single integral unit including an electrical processing circuit (217) which adapts a standard electrical signal for a specific application. 20
5. The system of claim 4, wherein the second location external equipment comprises a distributed data bus network (401). 25
6. The system of claim 4, wherein the second location external equipment comprises a hub (400) of a distributed data bus network (401). 30
7. A smart optical connector (100) comprising:
 - an optical cable (202); 35
 - an optical-electrical transducer coupled to the optical cable (202);
 - a microprocessor (220) coupled to the optical-electrical transducer, the microprocessor (220) capable of actively altering an electrical signal associated with the optical-electrical transducer (210); 40
 - an electrical interface including a first end and a second end (300), the electrical interface coupled at the first end to the microprocessor (220) and at the second end to external equipment (416); and 45
 - wherein the optical cable (202), the optical-electrical transducer (210), the electrical interface (300) and the microprocessor (220) are included in a single, integral package (222). 50
8. The connector of claim 7, wherein the single integral package (222) comprises an overmolded package. 55

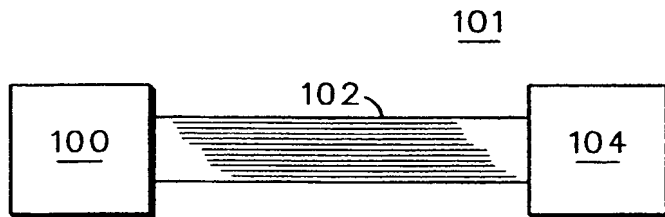


FIG. 1

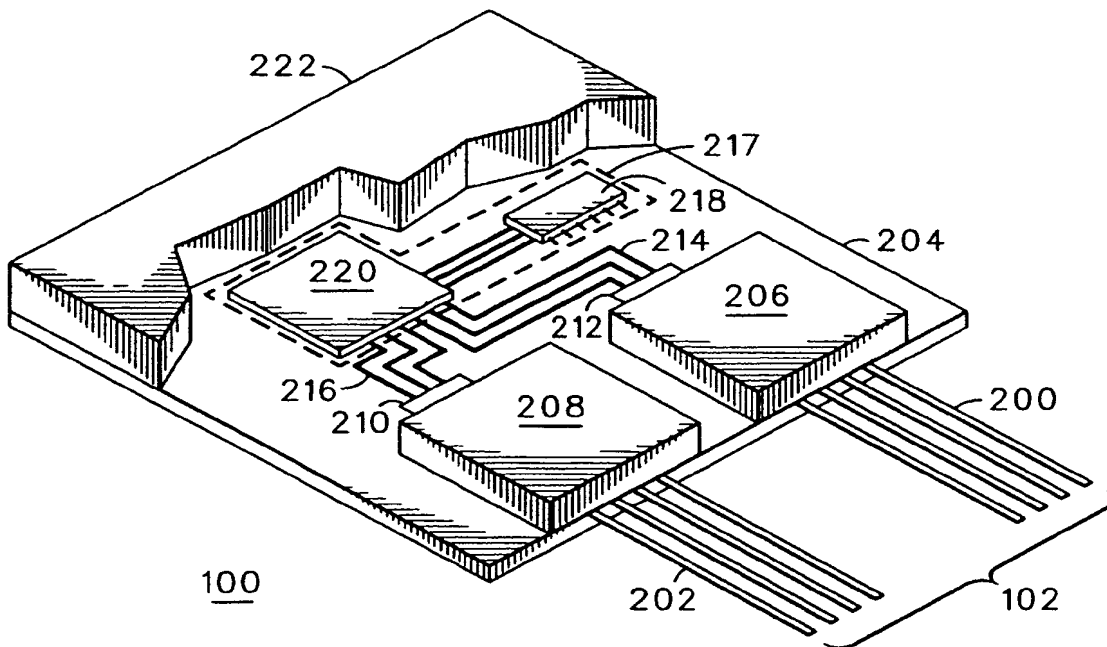


FIG. 2

FIG. 3

100

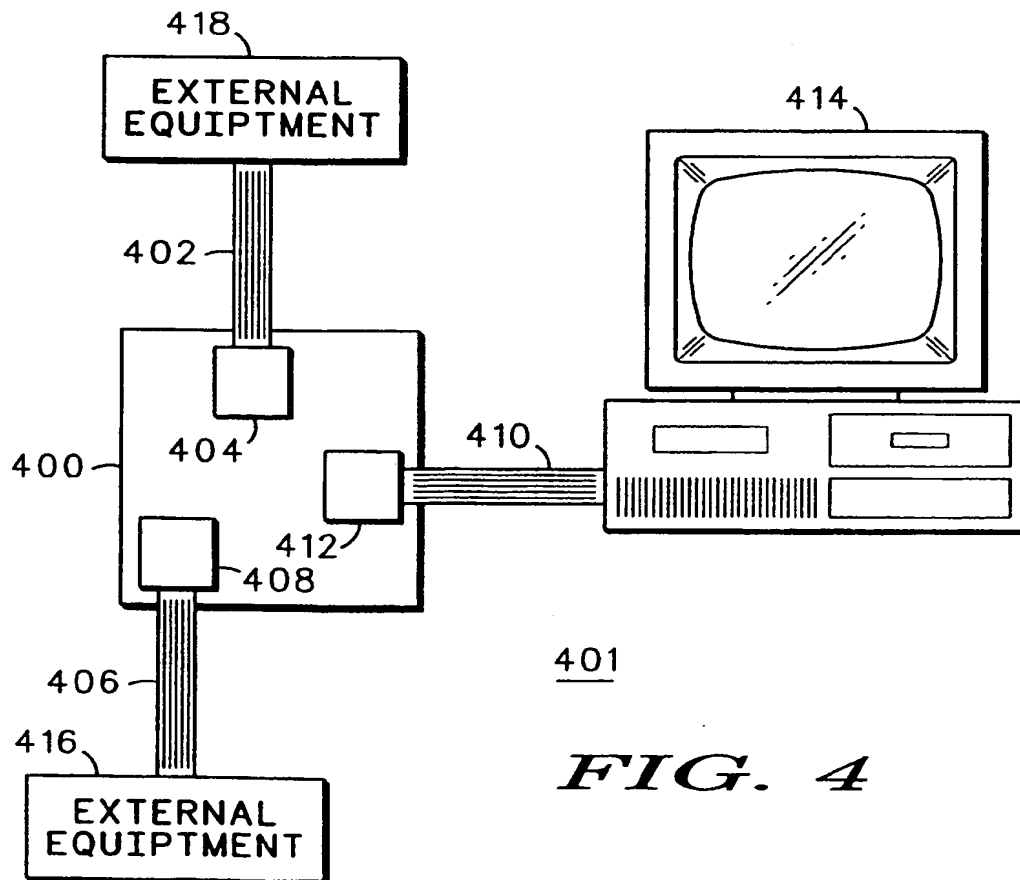
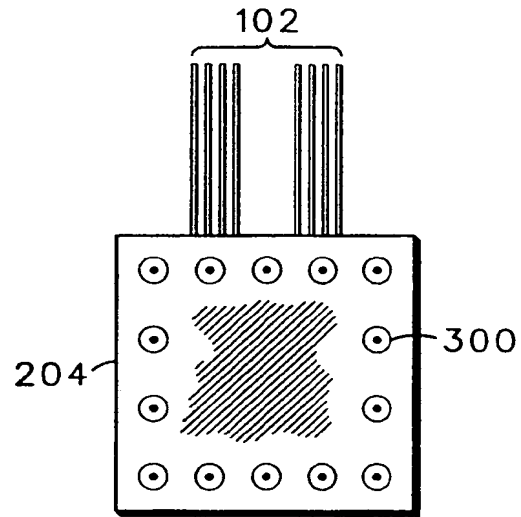


FIG. 4



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 94 11 4984

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION
X	EP-A-0 517 369 (NORTHERN TELECOM)	1,4	G02B6/42
Y	* column 2, line 5 - line 27 *	2,3,5-7	G02B6/38
A	* figure 2 *	8	

X	EP-A-0 412 528 (FUJITSU)	1	
	* column 9, line 13 - column 10, line 16 *		
	* figures 1,2 *		

Y	GB-A-2 218 570 (NATIONAL SEMICONDUCTOR CORPORATION)	2	
A	* page 5, line 23 - page 6, line 31 *	7	
	* figure 5 *		

Y	IBM TECHNICAL DISCLOSURE BULLETIN., vol.27, no.8, January 1985, NEW YORK US pages 4737 - 4738	3	
	R.A JARVELA 'PACKAGE FOR ELECTRICAL AND OPTICAL COMPONENTS OF COMMUNICATIONS PORT OF DATA PROCESSING SYSTEM'		
	* the whole document *		

Y	GB-A-2 260 836 (MOTOROLA)	5,6	TECHNICAL FIELDS SEARCHED (Int. CL. 6)
	* page 1, line 5 - line 8 *		G02B
	* page 7, line 26 - line 34 *		
	* figure 7 *		

Y	DE-A-34 36 135 (FUJI ELECTRIC)	7	
	* page 2, line 16 - page 3, line 19 *		
	* figure 1 *		

The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		12 January 1995	Luck, W
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone		T : theory or principle underlying the invention	
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